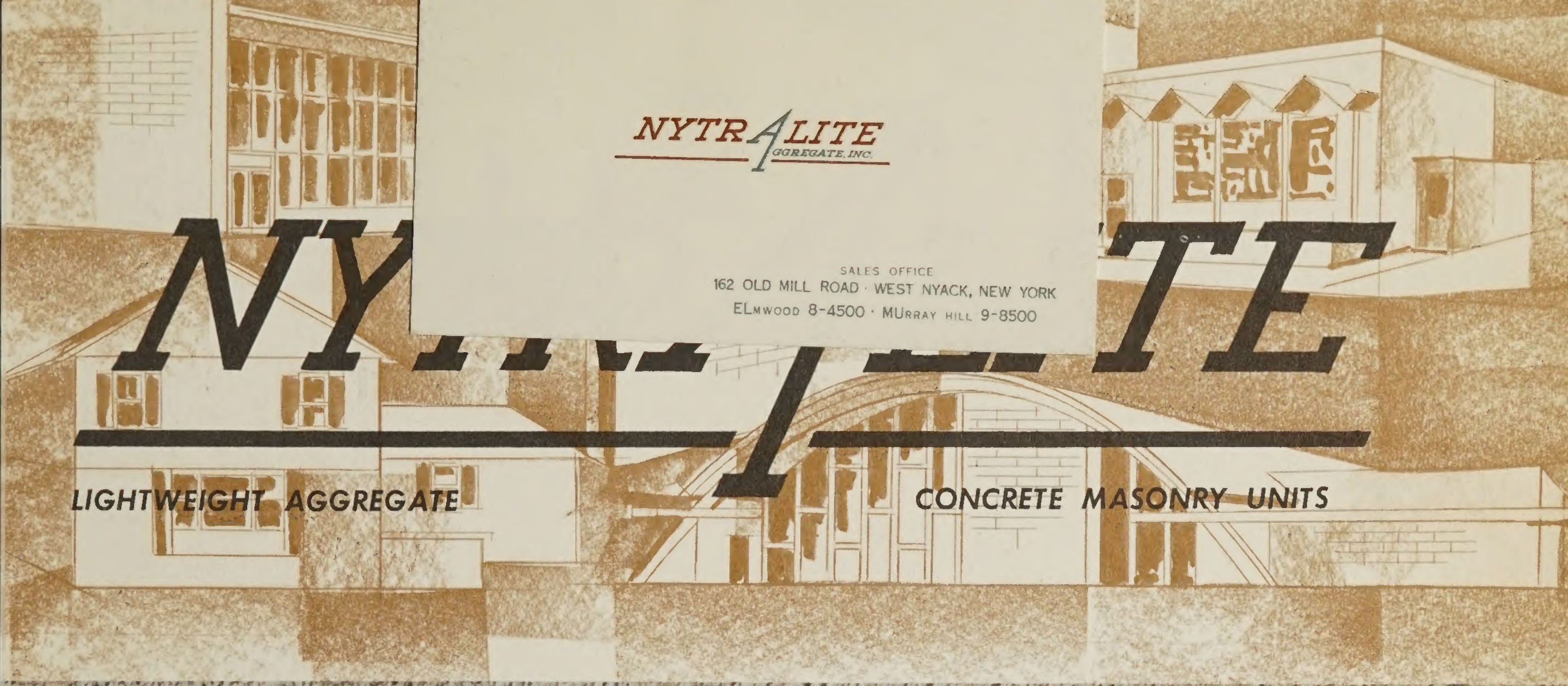

NYTRALITE AGGREGATE, INC.

SALES OFFICE
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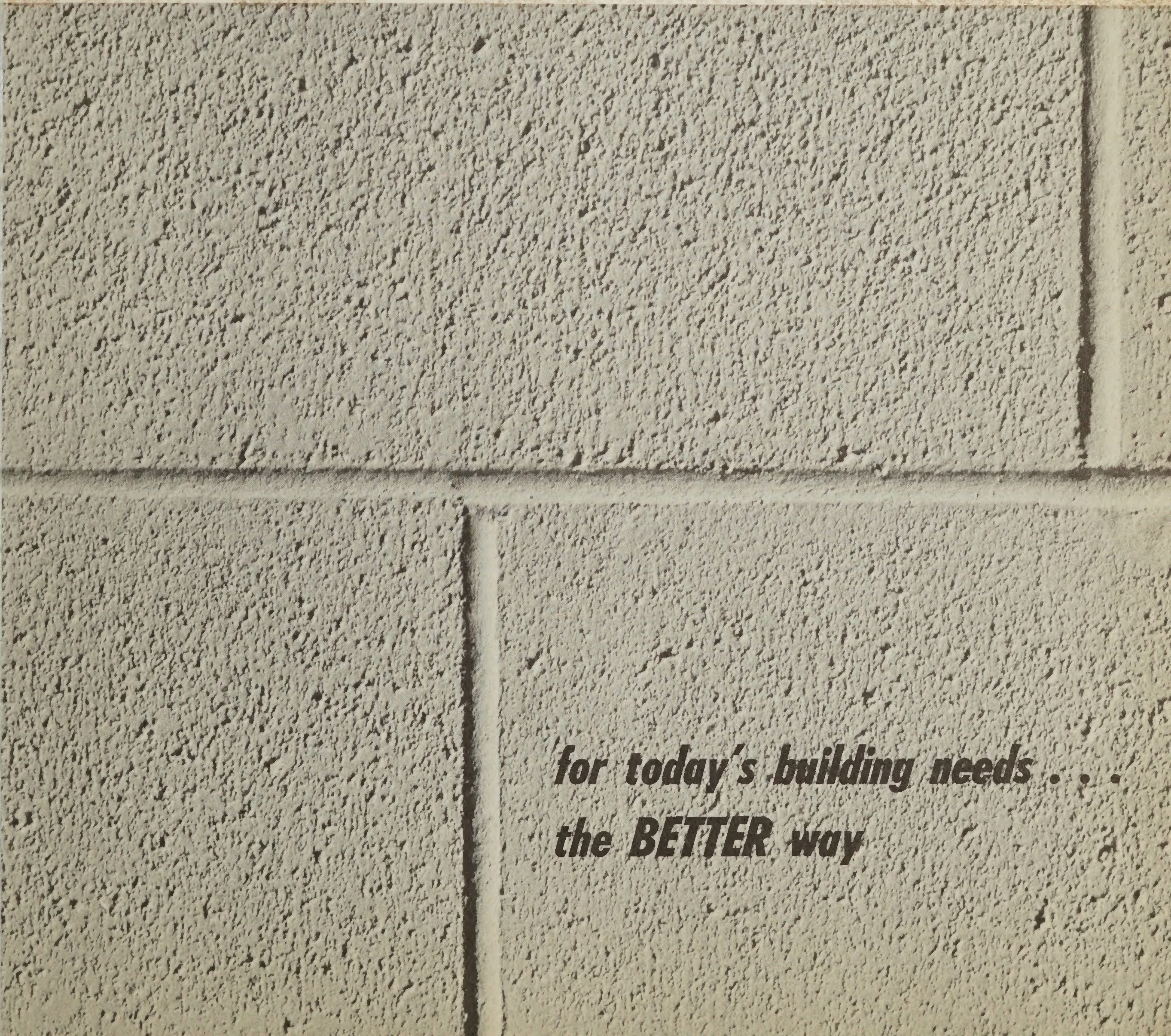
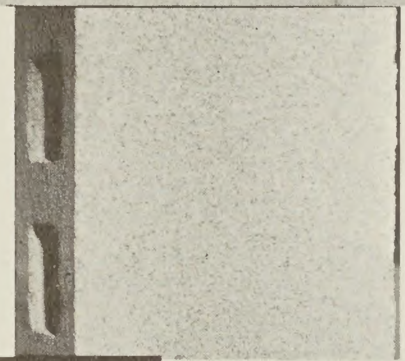
NY TE

LIGHTWEIGHT AGGREGATE

CONCRETE MASONRY UNITS



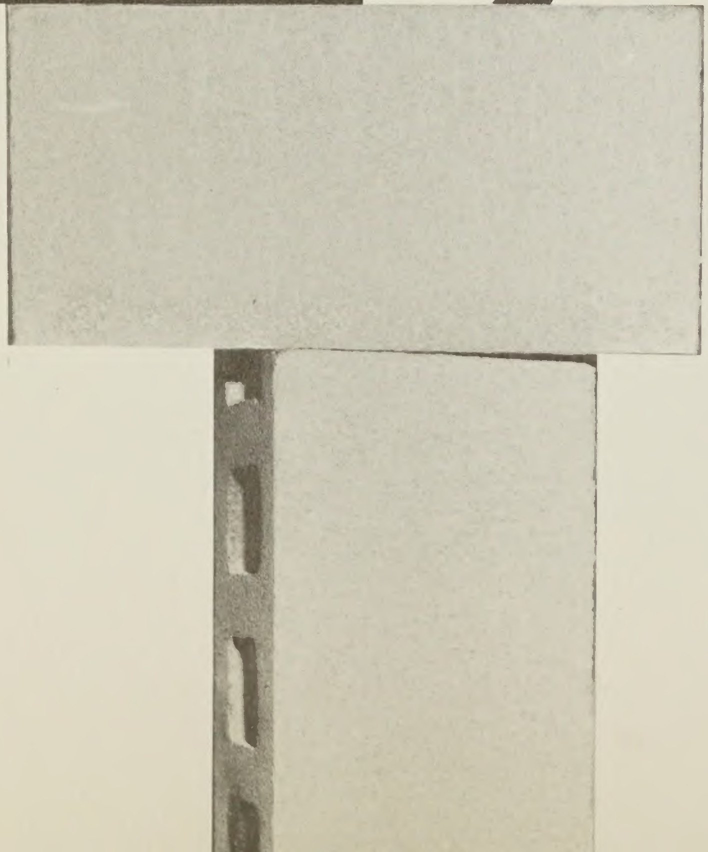
for today's building needs . . .
the BETTER way



- LIGHT WEIGHT ■
- HIGH STRENGTH ■
- ECONOMICAL ■
- QUALITY CONTROLLED ■
- EXCELLENT APPEARANCE ■
- EASIER TO HANDLE ■
- UNIFORM TEXTURE ■
- ACOUSTIC ADVANTAGES ■
- MINIMUM SHRINKAGE ■
- LOW ABSORPTION ■
- DURABLE ■
- NON-STAINING, NON-CORROSIVE ■

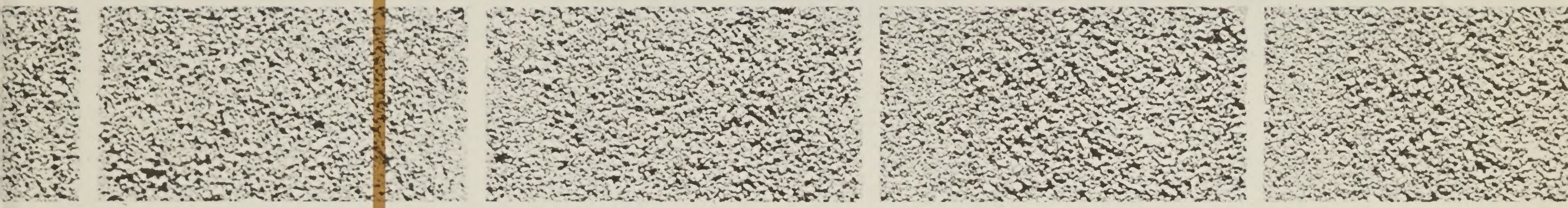
NYTRALITE MASONRY UNITS

SO MUCH LIGHTER . . . BUT JUST AS STRONG.



- HIGH INSULATION VALUE ■
- HIGHLY FIRE RESISTANT ■
- PLEASING, NATURAL FINISH ■
- ENDURING PAINT BASE ■
- MINIMUM MAINTENANCE ■
- NUMEROUS PATTERN POSSIBILITIES ■
- CLOSE DIMENSIONAL TOLERANCES ■

CONCRETE MASONRY MANUAL



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INSIDE

NYTRALITE is VERSATILE

Architects, engineers, contractors and property owners have become more and more aware of the value, economy and advantages of expanded shale concrete masonry walls—particularly NYTRALITE, the expanded shale lightweight aggregate produced by the rotary kiln method. NYTRALITE meets all ASTM, ACI, Federal and State specifications for lightweight aggregate.

This folder is your guide to the basic facts about NYTRALITE masonry units. It has been assembled with the aim of bringing together in one place the data required by the building industry in order to know fully the reasons why NYTRALITE masonry units show the way to better buildings and important cost savings. The superior qualities of masonry construction have long been recognized. Now NYTRALITE—lightweight with no sacrifice in strength – makes it possible to obtain the highest values in design, quality, workmanship, structural strength, resistance to weathering, fire resistance, climate control for interiors, acoustical properties, insulation . . . so many extra design features and benefits.

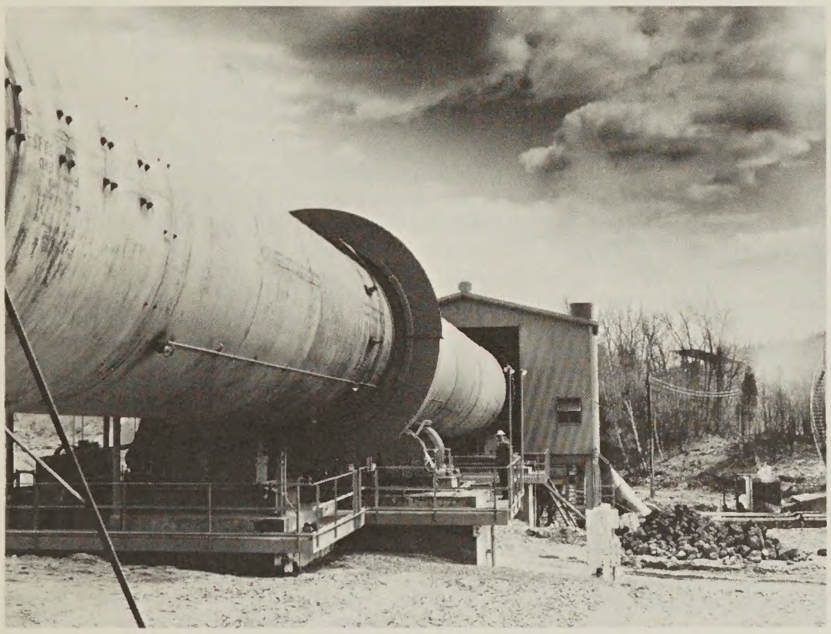
NYTRALITE is manufactured under rigid standards of quality control at a new, modern rotary kiln plant located in Kingston, N. Y. Our expanded shale processed lightweight aggregate, produced by extreme heats exceeding 2000 degrees, emerges as a hard, vitreous, chemically inert, exceptionally strong particle having a sealed or coated surface – a tough outer skin, so to speak – with a mass of tiny inner voids. The expansion cycle through which the shale passes is accompanied by an increase in volume and a decrease in density – the ideal combination for higher strength, light in weight aggregate having exceptional bonding properties and low absorption.

Bell Telephone pavilion at New York World's Fair. Nytralite masonry units used.

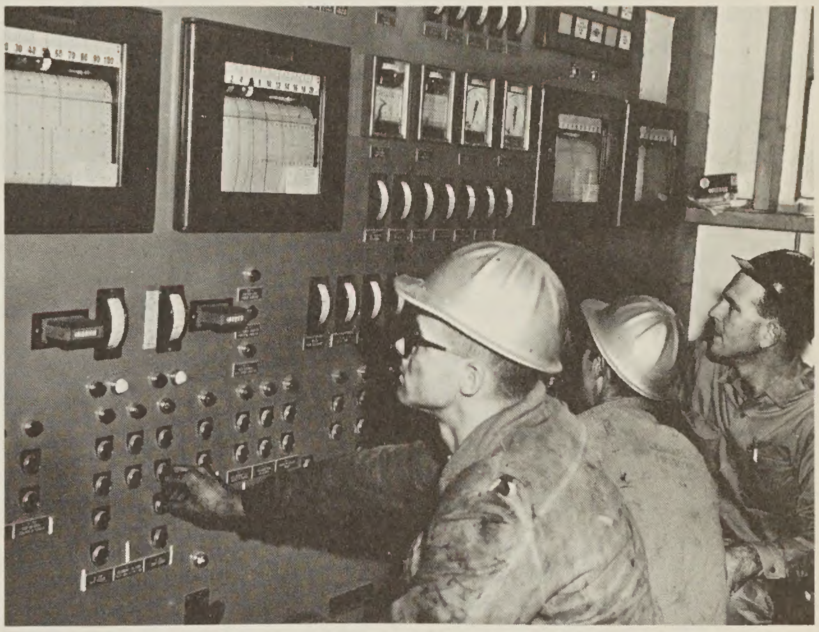
OR OUT

NYTRALITE

THE QUALITY CONTROLLED LIGHTWEIGHT AGGREGATE . . . HOW IT IS MADE

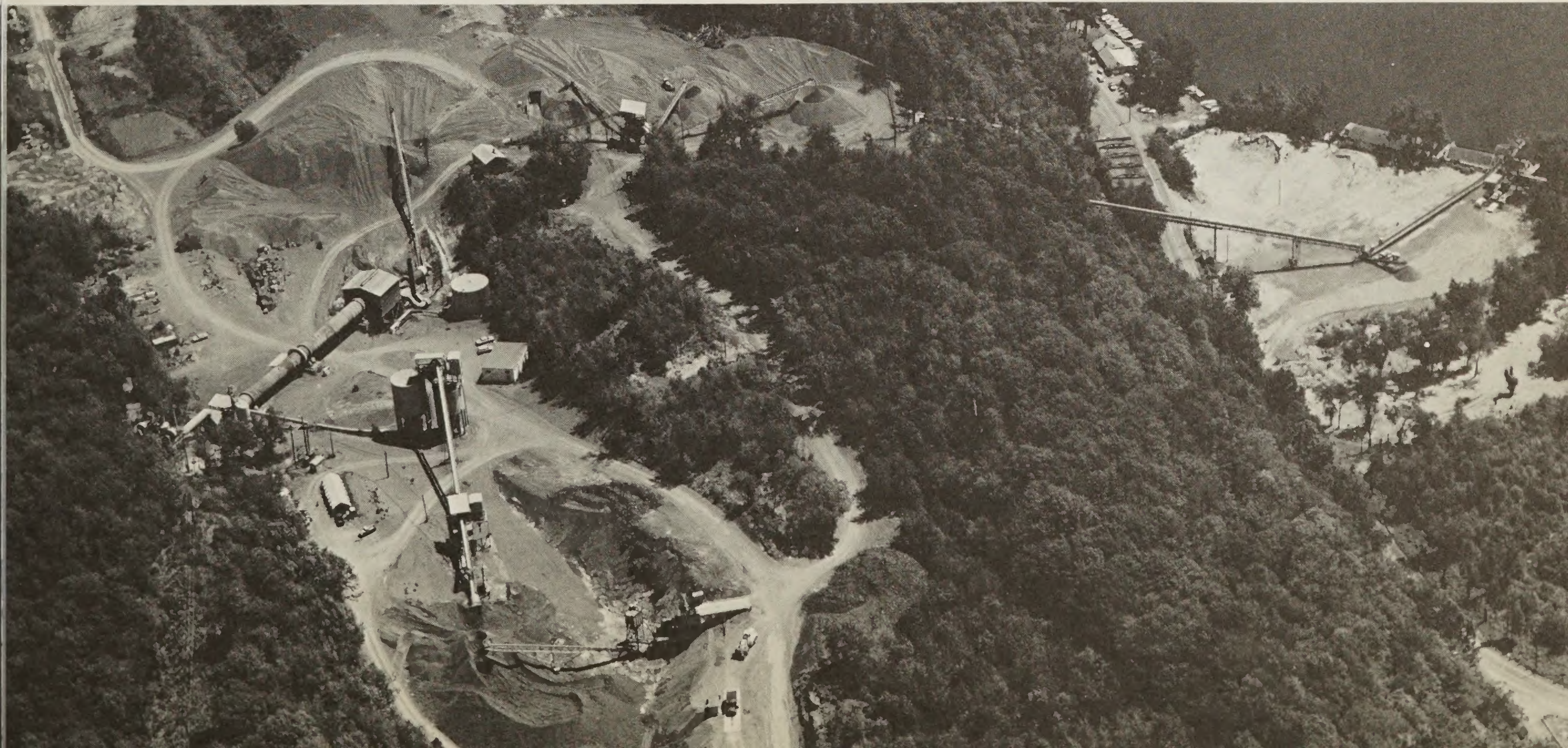


The rotary kiln in which coated, sealed, quality Nytralite is manufactured is of special design. It is the largest in the East.



Close-up of control panels at Nytralite plant. The entire operation is fully automated with instrumentation of the most modern design.

An aerial view of the Nytralite plant near Kingston, New York, on the Hudson River. A prime supply of high quality shale is available for the exacting requirements of the Nytralite operation.



NYTRALITE GUIDE SPECIFICATIONS

Quality concrete masonry construction depends not only on a high quality unit but also on a good design, good mortar, and good workmanship. Well-written specifications are essential to achievement of these objectives.

Lightweight concrete masonry made from NYTRALITE expanded shale lightweight aggregate, provides the high quality unit. To aid the architect in making utmost use of this product, these "Concrete Masonry Guide Specifications" are offered. On some projects certain items will not be applicable to the concrete masonry specifications. The specification writer should feel free to use those sections which pertain to the specific job and delete those sections which may not apply.

1.00. GENERAL

The masonry Contractor shall supply all labor, materials and equipment necessary to construct the lightweight concrete masonry walls of this project in accordance with plans and specifications. This work shall be properly coordinated with that of other trades. All applicable local laws, ordinances and codes shall be fully complied with. All materials, workmanship and construction practices shall be of a standard not less than that shown on the plans or specified hereunder.

2.00. MATERIALS

2.10. CONCRETE MASONRY UNITS

All concrete masonry units shall be manufactured from expanded shale, clay or slate aggregates, produced by the rotary kiln process, and conforming with ASTM Designation: C 331 "Lightweight Aggregates for Concrete Masonry Units". Weight of the concrete of which the units are made shall not exceed 95 lb. per cu. ft. when measured in accordance with the provisions of ASTM Designation: C 140 "Sampling and Testing Concrete Masonry Units".

All concrete masonry units shall conform with the following ASTM Designations: *(delete specifications not applicable)*

C 55 "Concrete Building Brick".
C 90 "Hollow Load-Bearing Concrete Masonry Units".
C 129 "Hollow Non-Load-Bearing Concrete Masonry Units".
C 145 "Solid Load-Bearing Concrete Masonry Units".

Masonry units shall be stacked on planks off the ground, and in wet weather shall be covered with tarpaulins or otherwise kept dry.

2.20. MORTAR

Mortar shall comply with ASTM Designation: C 270 "Mortar for Unit Masonry" either Property Specifications or Proportion Specifications *(specify either "Property" or "Proportion", not both)*, except that type O and K mortars shall not be permitted.

Property Specifications. Mortar shall comply with ASTM C 270 in all respects as it applies to property specifications. Mortar shall be type M, S or N *(specify one)* and have minimum compressive strength and water retention shown in Table 1, when tested in accordance with ASTM C 270.

Note: Proprietary plasticizers with a satisfactory performance record may be used as a mortar admixture where approved by the Architect and where tests show the mortar to meet the Property Specifications of ASTM C 270.

Proportion Specifications. Mortar shall comply with ASTM C 270, with proportions as shown in Table 2. Mortar shall be type M, S or N *(specify one)*.

Retempering. Mortar that has stiffened on the mortar board through evaporation may be retempered to restore its workability by thorough re-mixing and by the addition of water as required. Mortar which has stiffened on the board by hydration (setting) shall not be re-used and shall be discarded.

Note: Since it is difficult to distinguish visually between these causes of stiffening, the practical method of determining suitability of mortar is on the basis of time elapsed after initial mixing. Mortar should be used within 2½ hours when the air temperature is 80°F. or higher; within 3½ hours when the air temperature is below 80°F.

3.00. CONCRETE MASONRY WALLS

3.10. PATTERNS, BONDS AND TEXTURE

All walls shall be built plumb, true and level, to the thickness shown on the plans, and with the pattern detailed on the drawings. Where no pattern is indicated, running bond shall be used.

Concrete masonry units that are exposed in walls, either natural finish or painted, shall have a uniform texture reasonably close to samples approved by the Architect. They shall be free of imperfections in the surface which would impair the finished appearance.

3.20. JOINTS

Joints on all exposed surfaces shall be concave joints, V-joints, raked joints, flush joints, weathered joints or extruded joints (*specify which*).

The concave joints and V-joints shall be formed by striking the mortar flush, and after it is partially set, tooling with the proper shaped tool to adequately compact the surface. The tool used on horizontal joints shall be of sufficient length, not less than 20 in., so that a uniform joint is formed free from waves. Special tools may be used to shape the weathered joints and raked joints.

Where walls are to be stuccoed, the joints shall be struck flush. Where flush joints are to be exposed, they shall be first compacted, then re-pointed, and excess mortar removed.

The raked joint and extruded joint shall not be used for exterior walls except in relatively dry climates.

3.30. CONTROL JOINTS

Control joints shall be located where shown and as detailed on the plans. Control joints shall form a continuous vertical break from foundation to top of wall or to bond beam, or from bond beam to bond beam. Provision shall be made for adequate lateral stability (detail on plans). Control joints shall be filled with mortar, raked back ¾ in., and pointed with an approved, non-hardening calking compound. The calking compound shall be tooled to match mortar joints or struck flush, as shown in details. No masonry joint reinforcement shall extend across a control joint.

3.40. JOINT REINFORCEMENT

The masonry Contractor shall provide and place horizontal joint reinforcement, prefabricated from zinc coated, cold drawn steel wire conforming with ASTM Designation: A 83, and of a type or design approved by the Architect, where shown on the plans.

Joint reinforcement shall be placed in two consecutive joints above and below windows and other openings. It shall extend 24 in. beyond the openings on each side, unless a control joint or joints are located at the openings, in which case the joint reinforcement shall terminate at the control joints.

3.50. BOND BEAMS

Bond beams shall be located where shown and as detailed on the plans. Bond beam units shall be filled with concrete having a minimum strength of 2500 psi at 28 days. They shall be reinforced with not less than two No. 4 deformed bars or as shown on plans.

3.60. SPECIAL UNITS AND DETAILS

The masonry Contractor shall provide and place all special units required or as shown on plans, including solid units, bond beam units, lintel units, sash jamb units, plain end units, bullnose corner units, etc. Where such units are not available from the supplier they shall, where possible, be cut on the site, using a power masonry saw.

Note: The Architect should determine beforehand what standard units and special units are locally available and design accordingly insofar as possible. Job-site cutting should be confined to simpler cuts and kept to a minimum.

At the tops of all walls, and under joists, beams or other concentrated loads, solid blocks shall be provided unless a bond beam or other detail is shown. Where loads do not exceed 40 lbs. per lineal foot, the top course may be filled with compacted mortar or concrete, in which case a layer of metal lath or closely spaced mesh shall be placed in the joint below to positively hold the mortar when rodded into the core spaces.

Note: A bond beam serves other structural purposes and is to be preferred. Filling of cores on the site should be permitted for lighter joist loads only when filling is adequately supervised.

The masonry Contractor shall place all anchor bolts for wood plates, setting them in mortar, and shall make provision for the building in of other details and appurtenances shown on the plans.

3.70. WEATHERPROOFING

All concrete masonry walls exposed to the weather or below ground shall be adequately weatherproofed or waterproofed, using an approved paint or other coating and applied in accordance with the directions of the manufacturer. This may include stucco, portland cement paint, acrylic emulsion paint, polyvinyl acetate, or other proven waterproofing treatments.

3.80. INTERSECTING BEARING WALLS

Intersecting bearing walls shall not be tied together in a masonry bond, except at the corners. Instead, one wall shall terminate at the face of the other wall with a control joint at that point. For lateral support, bearing walls shall be tied together with a metal tiebar ¼ in. thick, 1¼ in. wide, and 28 in. long, with 2-in. right angle bends on each end. Tiebars shall be spaced not more than 32 in. apart vertically. The bends at the end of the tiebars shall be embedded in cores filled with mortar or concrete. Pieces of metal lath shall be placed under the cores to support the concrete or mortar filling.

If the control joint at the intersection of the two bearing walls is to be exposed to view or subjected to weathering, the mortar shall be raked out to a depth of ¾ in. and sealed with a calking compound.

3.90. INTERSECTING NONBEARING WALLS

For tying nonbearing walls to other walls, strips of metal lath or ¼-in. mesh galvanized hardware cloth shall be placed across the joint between the two walls. The strips shall be spaced not more than 16 in. apart vertically. When one wall is constructed first, the strips shall be built into the wall and later embedded in the mortar joints of the second wall.

If the joint where the two walls meet is to be exposed to view, the mortar shall be raked out to a depth of ¾ in. and sealed with a calking compound.

4.00. CONSTRUCTION OF CONCRETE MASONRY WALLS

4.10. LAYING UP THE UNITS

All face shell and end joints shall be fully filled with mortar and joints shall be squeezed tight. Slushing of mortar into joints shall not be permitted. The first course of blocks shall be laid in a full bed of mortar.

The masonry units shall not be dampened prior to laying but shall be laid up in the dry state.

Note: In certain areas during protracted periods of hot and dry climate conditions it may be necessary to dampen block just prior to laying. It is suggested that local good practices be followed in these extreme conditions.

4.20. PROTECTION

At the end of each day's work the top of the wall shall be covered with tar paper or polyethylene sheets, or by other means protected from becoming excessively wet.

Basement walls shall not be backfilled until the first floor is in place. Other walls shall be adequately braced during construction to prevent damage from high winds.

4.30. CLEANING

Walls which are to be left exposed should be kept clean during progress of the work. Mortar smears shall be allowed to dry for a short period and then shall be promptly removed by trowel or fiber brush or both. Care shall be taken to avoid damage to the mortar joint when brushing. Mortar burrs shall be promptly removed with the trowel.

At the conclusion of the work, walls shall be cleaned down and all scaffolding and debris removed.

TABLE 1

Compressive Strength and Water Retention of Mortars

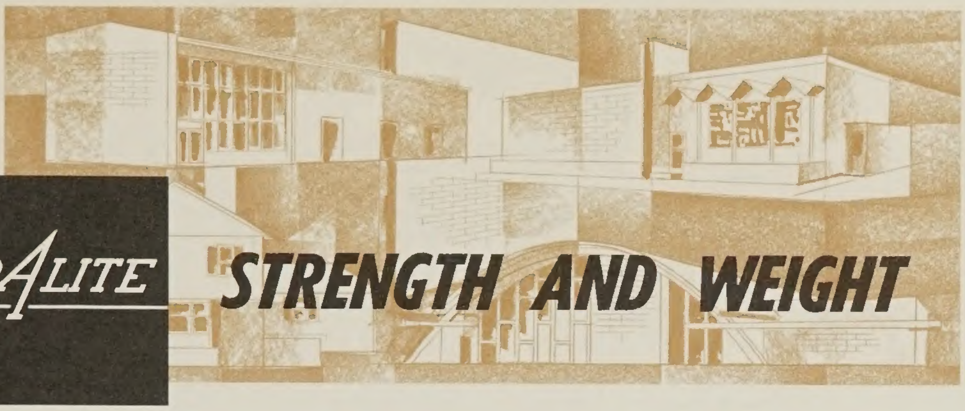
Mortar Type	Average* Compressive Strength at 28 Days, p.s.i.	Water Retention Flow After 1 Min. Suction
M	2500	70%
S	1800	70%
N	750	70%

* Of three 2-in. cubes

TABLE 2

Mortar Proportions by Volume

Mortar Type	Parts by Volume of Portland Cement	Parts by Volume of Masonry Cement	Parts by Volume of Hydrated Lime or Lime Putty	Aggregate, Measured in a Damp, Loose Condition
M	1 1	1 (type II) —	— ¼	Not less than 2¼ and not more than 3 times the sum of the volumes of the cements and lime used.
S	½ 1	1 (type II) —	— ¼ to ½	
N	— 1	1 (type II) —	— ½ to 1¼	



NYTRALITE STRENGTH AND WEIGHT

STRENGTH

Concrete masonry units in most localities, depending on usage, are required to meet certain strength requirements. While municipal, federal and other government agencies may have their own codes covering acceptable quality, the most widely used specifications are those of the American Society for Testing and Materials.

Expanded shale masonry units, though much lighter in weight than normal weight aggregate concrete blocks, are designed to meet the same strength requirements. Table 3 summarizes the strength requirements of three A.S.T.M. specifications to which expanded shale masonry conforms.

The strength of concrete masonry units is measured as the breaking strength in compression expressed as pounds per square inch (psi). This may be calculated on the gross area of block, the net area of concrete, or both as required by the specification.

For example in ASTM C 90-64T, Grade "U" block are required to have an average compressive strength of not less than 1000 psi on the gross area as well as a minimum of 2000 psi on the net concrete area of the section, whereas Grade "P" block are required to have an average of not less than 1000 psi on the gross area only. In order to meet Grade "U" requirements, a unit with a net area of concrete greater than 50% of the gross section area will automatically have a gross area compressive strength greater than 1000 psi and the minimum net area strength requirement of 2000 psi will control.

The purpose of both gross and net area strength requirements for Grade "U" block is to ensure that block used for below grade construction are manufactured from concrete having a minimum compressive strength of 2000 psi regardless of the face shell thickness, core volume or web thickness of a particular unit.

The superiority of expanded shale masonry is inherent in the aggregate itself. Specifically produced as a structural concrete aggregate, it has the highest crushing strength of any lightweight aggregate. There is no breakdown of the aggregate in the mixer or block machine, enabling the block manufacturer to more easily maintain control of strength, texture and weight.

WEIGHT

The weight of expanded shale masonry is generally the lowest of all masonry units of comparable strength. The weight of any unit will depend on its exact size, on the core volume, and on the mix used by the manufacturer. Therefore, there will be some difference between one area and another and the block producer should be consulted for his standard weights.

Obviously, the lowest weight, without sacrifice of strength, results in added economy due to lighter loads on the structural frame and foundation. It also means a considerably lower weight of material to be handled by the mason, or conversely, he is able to lay more blocks per day with the same expenditure of effort.

Note: The 8-8-16, 2-core expanded shale masonry units with 1¼-in. face shell weigh from 20 to 28 lbs. throughout the industry.

TABLE 3

Masonry Units and A.S.T.M. Specification	Type and Grade Designation	Min. Compressive Strength, psi			
		Ave. Gross Area		Ave. Net Area	
		Ave. of 5 Units	Individual Unit	Ave. of 5 Units	Individual Unit
Hollow Load-Bearing Concrete Masonry Units ASTM C 90-64T	U-I, U-II	1000	800	2000	1600
	P-I, P-II	1000	800	—	—
	G-I, G-II	700	600	—	—
Solid Load-Bearing Concrete Masonry Units ASTM C 145-64T	U-I, U-II	1800	1500	2000	1675
	P-I, P-II	1800	1500	—	—
	G-I, G-II	1200	1000	—	—
Hollow Non-Load-Bearing Concrete Masonry Units ASTM C 129-64T	Types I or II	350	300	—	—

Grade	Intended Use
U	Unprotected exterior walls below grade. Unprotected exterior walls above grade which may be exposed to frost action.
P	Protected exterior walls below grade. Protected exterior walls above grade that may be exposed to frost action.
G	General use above grade — in walls not subject to frost action — in walls protected from weather.

Type	Definition
I	Moisture-controlled units conforming to all requirements of applicable specifications including the moisture-content requirements listed in Table 7, page 18.
II	Nonmoisture-controlled units conforming to all requirements of applicable specifications except the moisture-content requirements listed in Table 7, page 18.

At New York's renowned Lincoln Center for the Performing Arts, Philharmonic Hall, Nytralite masonry units were used throughout.

NYTRALITE FIRE RESISTANCE

A.S.T.M. methods of testing building materials for fire resistance are designed to determine the fire-resistive properties of materials and assemblies in accordance with a common standard. The test consists of exposing the material or assembly to a fire of controlled extent and severity. Performance is defined as the elapsed period of time of resistance to this standard exposure before the first critical point in behavior is observed, and is reported in hours.

As a matter of general interest, the standard controlled fire test calls for furnace temperatures of 1000 degrees F. in 5 minutes, 1700 degrees F. in 1 hour, and 2000 degrees F. in 4 hours.

In 1958 the Underwriters' Laboratories reported a series of fire tests on expanded shale concrete masonry representative of nation-wide standard production. The program was designed to furnish fire resistance ratings on the commercially available A.S.T.M. Class A expanded shale block, and to furnish ratings on a basis of equivalent thickness and face shell thickness of 8-in. units. In 1963-64 the National Research Council of Canada reported a series of fire tests on expanded shale concrete masonry partition walls, based on the equivalent thickness of the unit. "Equivalent thickness" is defined as the average thickness of the solid material in the wall. It is determined by dividing the volume of concrete in the unit by the face area of the unit.

Table 4 gives the fire resistance rating of expanded shale concrete masonry.

TABLE 4

NYTRALITE EXPANDED SHALE CONCRETE MASONRY UNITS

(Consult your masonry manufacturer for specific units available in your area)

Description Nominal thickness, unless stated otherwise	1½ hour	2 hours			3 hours			4 hours		
	% Solid	% Solid	Equivalent Thickness (in.)	Face Shell Thickness (in.)	% Solid	Equivalent Thickness (in.)	Face Shell Thickness (in.)	% Solid	Equivalent Thickness (in.)	Face Shell Thickness (in.)
Natl. Board of Fire Underwriters Fire Resistant Ratings Dec. 1964										
Steel Column Protection										
4 in. (actual), 1½ in. space between column and masonry units, no fill								100		
Walls										
Brick faced										
6 in. units, unplastered, faced with 2¼ in. brick								61		
Plastered										
4 in. units, plastered on one side with ½ in. 1:3 gypsum and sand plaster		76								
3 in. units, plastered on both sides with ½ in. 1:3 gypsum and sand plaster	76									
Unplastered										
6 in. units, unplastered		68.8	3.59							
4 in. units, unplastered		100	3.40							
6 in. units, unplastered	61									
8″ or 12″ units				1⅛			1⅜			
8″ or 12″ units			4.20	1¼ *		4.85	1½ *		5.35 4.20**	1¾ *
Estimated Ratings			3.80			4.80			5.70	
Underwriters' Laboratories Standards for Safety UL 618, Aug. 1958										
Walls										
Table I										
1:7 Mix — not less than 8″ units				1⅛			1⅜			
Table II										
1:9 Mix — not less than 8″ units			4.20	1¼ *		4.85	1½ *		5.35 4.20** 4.85**	1¾ *
National Fire Protection Handbook, 1962										
Walls										
1:7 Mix — 8″ units		54		1⅛	62		1⅜	68		1⅝
National Research Council of Canada										
Walls										
Report #10, 1963 6″		68.8	3.59							
Report #11, 1964 4″		100	3.40							
Report #12, 1964 6″								89.1	4.71	

This table is prepared as a guide. For additional specific requirements, please refer to the source indicated.

---

*Approximate.

**Cores filled with expanded shale. See U.L. Building Materials List January 1964.

***8″ and 12″ units rated as load bearing with noncombustible or no members framed into wall. See N.B.F.U. Fire Resistant Ratings or U.L. Building Material List.

NYTRALITE

SOUND TRANSMISSION LOSS THROUGH CONCRETE MASONRY WALLS

The control of sound in rooms of buildings may be classified with respect to the origin of the sound — namely, sounds originating within the room and sounds originating outside the room. Efficient and economical control of sound is dependent not only upon its origin, but also upon the design of the enclosure and type of occupancy.

For reduction of sound originating within a room, the sound absorption qualities of the walls, ceiling and flooring, as well as furnishings are important. The type and use of the room affords the architect latitude in the selection of sound absorption materials for elements of the room. Enclosures with high ceilings and large expanse of wall areas, as in gymnasiums and churches, might utilize sound absorbing textured masonry walls as an economical solution. On the other hand, enclosures with relatively low ceilings, and rather small exposed wall areas, as in offices and schoolrooms, acoustical ceilings, floor covering, and interior furnishings might be the more effective solution.

This information sheet is concerned primarily with the suppression of sound originating outside the room by evaluating the transmission loss through concrete masonry partitions. These sounds are transmitted as solid-borne, as well as air-borne noise. For example, a bare concrete floor transmits the sound of footsteps between rooms, the sound traveling through the rigid concrete slab. Solid-borne sound should be suppressed at the source. A concrete floor for example, should be either broken at partitions, or covered with some type of resilient material, depending upon the extent of solid-borne sound transmission which should be suppressed.

Air-borne sound may be reduced and/or suppressed by barriers such as concrete masonry partitions. Obviously, attention should be given to doors and their closures, as well as connections of the walls at the ceilings and floors. Too often the effectiveness of a concrete masonry partition which should provide satisfactory acoustical isolation is unnecessarily lost. This may occur by failure of the designer to take into account the other important factors that are involved, such as continuing the partition to the structural ceiling. Also, he should avoid cutting of continuous holes through the wall for ducts, electrical outlets, etc.

SOUND ENERGY MEASUREMENTS

Sound energy is measured in decibels. The decibel is a convenient unit because it is approximately the smallest change in energy that the ear can detect.

The following table of sound intensities will aid in an understanding of decibel values.

TABLE 5[1]

160	Near jet engine
130	Threshold of painful sounds; limit of ear's endurance
120	Threshold of feeling (varies with frequency)
105	Express train passing at high speed
100	Loud automobile horn, 23 feet away
80	A subway
70	A stenographic room
60	Average busy street
55	Noisy office or department store
50	Moderate restaurant clatter
45	Average office
35	Soft radio in apartment. The average residence.
20	Average whisper four feet away
10	Rustle of leaves in gentle breeze
0	Threshold of audibility

According to various studies, the weight per unit of wall area is a most important factor influencing sound transmission loss. Knudsen and Harris[2] have presented a chart representing the average relationship between transmission loss and weight of the barrier. This chart was published in the November, 1956 issue of the ACI Journal[3] on logarithmic coordinates. Figure 1 represents this relationship plotted on linear coordinates. Porous materials, such as concrete masonry, may be expected to follow this transmission loss-weight relationship, *provided the pores are not continuous.* It therefore follows that effectively sealing one or both sides of concrete masonry partitions is highly desirable.

Figure 1 presents rather clearly the decreasing value of wall weight in effecting sound transmission loss. It will be noticed that whereas the first 15 lbs. per square foot of wall area furnish a loss of 40 decibels, the next 15 lbs. per square foot increase the loss only 5 decibels.

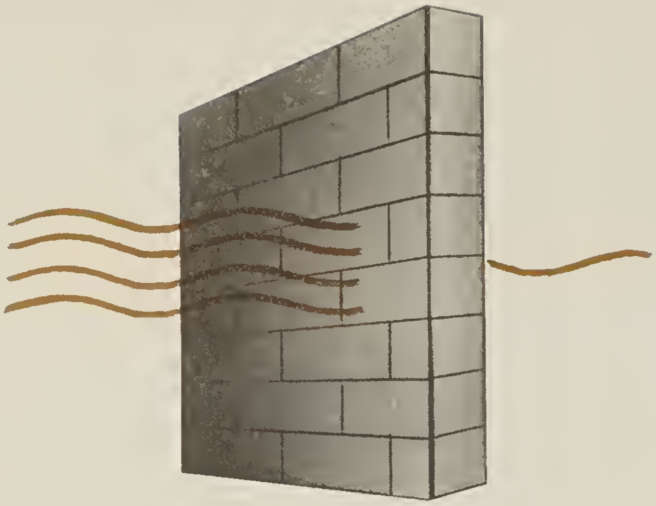
Figure 2 relates transmission loss to the weight of concrete masonry units. The losses in these charts take into account the weight of the mortar required to lay the wall.

---

[1] Building Materials and Structures Report 144, National Bureau of Standards.

[2] V. O. Knudsen and C. M. Harris "Acoustical Designing in Architecture" John Wiley & Sons, 1950.

[3] R. C. Valore, Jr., "Insulating Concretes" ACI Journal, November, 1956, p. 509.



USE OF DIAGRAMS

An accurate computation for the sound transmission loss through masonry partitions is much more involved than this presentation, but it is believed that for practical usage in the majority of situations this simplified presentation will be found satisfactory. Obviously, for music practice rooms, recording studios, critical patients' hospital rooms and the like, a more accurate and thorough analysis of sound suppression should be employed.

In the following discussion the general effect of masking is disregarded due to the nature of conditions considered. For practical purposes, it is assumed that the extraneous noises in and around the structure under consideration are the same. In the suburbs the general noise level is low, whereas if the same structure were located in the downtown section of a busy city, the general noise level would be 30 or 40 decibels higher. Thus, sounds of soft music which could be heard in the suburbs would be drowned out in the downtown section. The major noise level with which this information sheet is concerned is that originating within the structure.

The architect in considering the reduction of sound through walls separating rooms of schools, hotels, or office buildings for example, is concerned with reducing a sound intensity of, say, 55 decibels to something on the order of 15 decibels or less. He is able to select these values by referring to Table 5. Referring to Figure 2 and the curve representing an expanded shale masonry unit with an 8" x 16" face, it is found that a unit weighing 15 lbs. air dried, will offer a transmission loss of approximately 42 decibels (if properly sealed). The average 4-8-16 expanded shale masonry unit weighs approximately 15 lbs. air dried, therefore a partition wall made of these units can be expected to reduce the sound transmission satisfactorily for the assumed situation, provided of course, the surfaces of the wall are sealed sufficiently to prevent the direct passage of sound through the voids.

SURFACE SEALING

As has been stated above, porous materials such as concrete masonry may be expected to follow the transmission loss-weight curve if the pores are not continuous. Thus, sealing the wall is necessary to obtain the acoustical isolation shown in Figure 2. Walls that have not been sealed may show much lower decibel losses, in some instances 40 to 50 percent of the values shown in Figure 2.

Expanded shale concrete masonry units are furnished with a variety of textures which may be classified as ranging from "fine-tight" to "coarse-open". Units with a "fine-tight" texture with "slick" on the surface may be readily sealed with a single coat of paint. Units with a somewhat coarser texture are also easily sealed with the proper application of a continuous coat of paint. Units with a "coarse-open" texture will require a little more attention. It is recommended that two coats of paint be applied in order to provide a continuous paint film. Two coats of paint properly applied, while sealing the wall, need not necessarily eliminate the appearance of "rough-surface".

Tests have indicated that in addition to plaster, portland cement base paints and polyvinyl acetate, acrylic emulsion and other latex base paints properly applied have proven highly effective in sealing the surfaces of concrete masonry walls.

The above types of paints are furnished in a variety of colors and when applied in accordance with the manufacturer's recommendations, not only effectively seal the surfaces of the masonry walls, but also offer the architect a pleasant variety of color and color combinations for decorating purposes. In addition, with expanded shale concrete masonry, there are a variety of bonds and patterns in which the units may be laid in order to achieve further variety in the architectural treatment of interiors, and still maintain effective sound transmission loss.

CONCLUSIONS

With the general principles outlined in this information sheet, it is seen that considerable latitude is afforded the designer in his approach to sound control with concrete masonry. For example, with a single unit wall separating a classroom and a corridor, a medium-open textured concrete masonry unit could be used, by plastering or thoroughly sealing with paint the classroom side. The corridor side, left unpainted, would reduce the corridor sounds by absorption, and the sealing would enable the wall to perform as an effective sound barrier to the corridor sounds. Where cavity wall construction is used for wall partitions, open-textured units may be used provided back plastering on one side of the cavity is employed to seal the wall. These are but a few of the many approaches for the efficient use of concrete masonry.

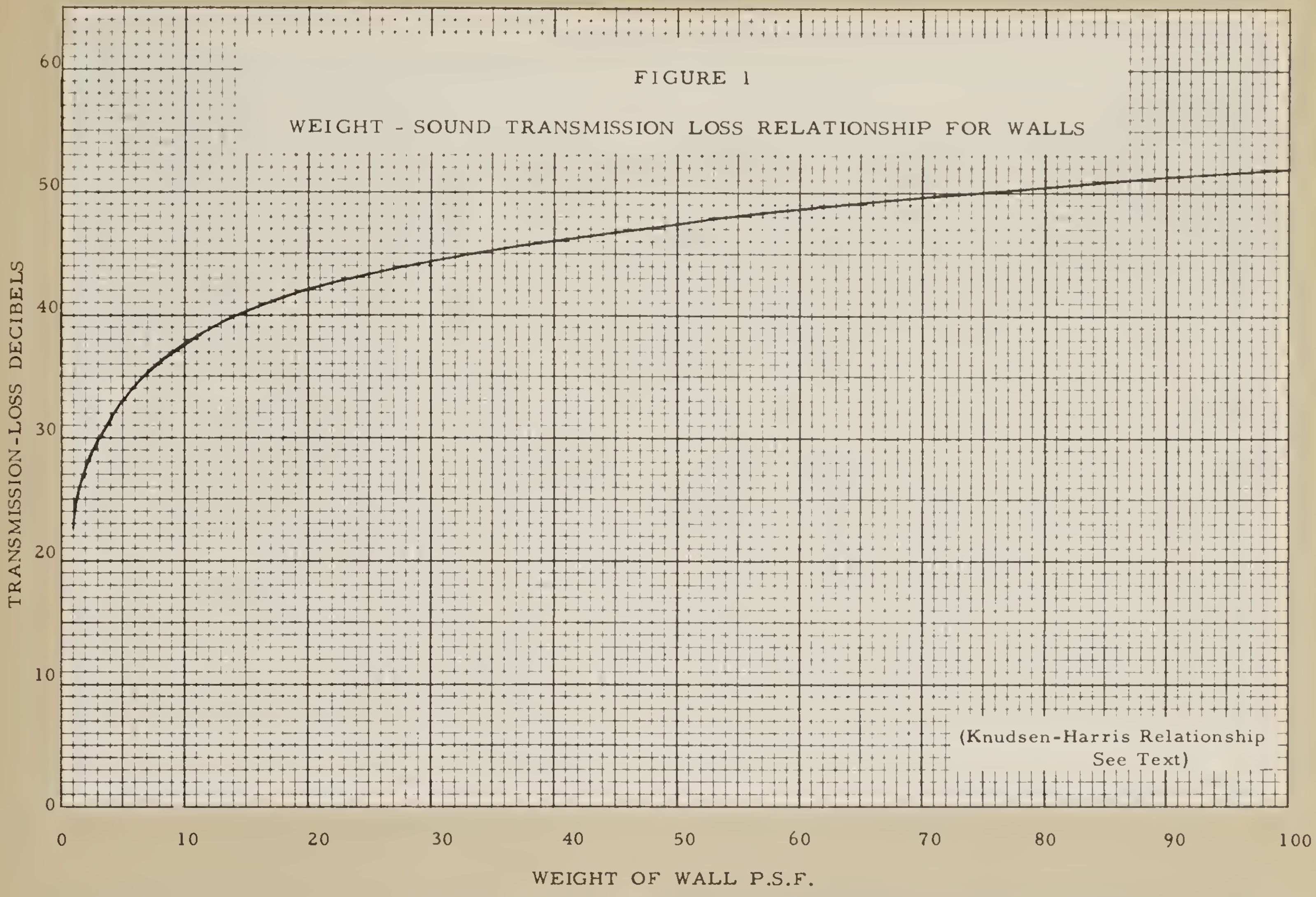


FIGURE 1

WEIGHT - SOUND TRANSMISSION LOSS RELATIONSHIP FOR WALLS

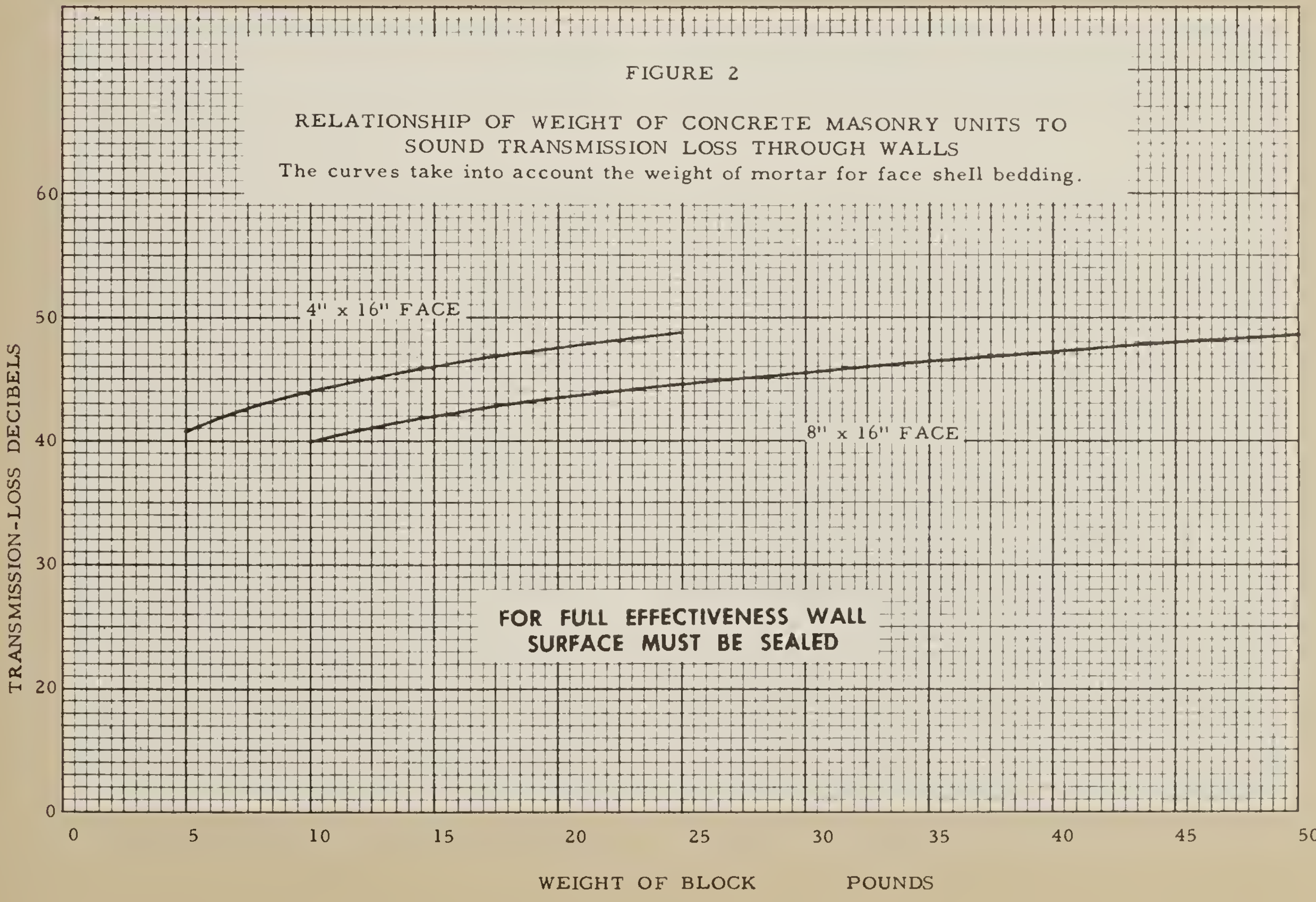


FIGURE 2

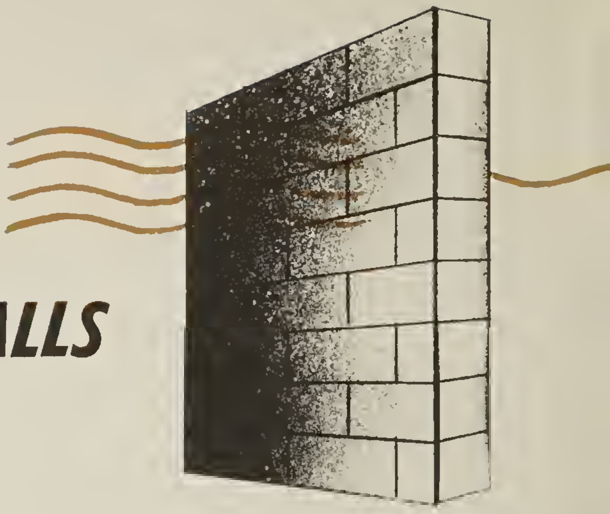
RELATIONSHIP OF WEIGHT OF CONCRETE MASONRY UNITS TO SOUND TRANSMISSION LOSS THROUGH WALLS

The curves take into account the weight of mortar for face shell bedding.

FOR FULL EFFECTIVENESS WALL SURFACE MUST BE SEALED

NYTRALITE

SOUND ABSORPTION OF CONCRETE MASONRY WALLS



INTRODUCTION

Sound absorption control deals with the reduction and control of sound emanating from a source *within* the room. Control is dependent on the shape as well as on the efficiency of the many surfaces in the room in absorbing (i.e. not reflecting) sound waves.*

The study of sound conditioning and acoustical control is a highly specialized field, and for a thorough and accurate solution, particularly of special problems, authorities on the subject and more detailed manuals should be consulted. This data sheet will serve as an introduction to some of the principles involved.

PRINCIPLE OF CONTROL

Sound waves created by voices, equipment, and other sources, radiate in all directions in a room until they strike some surface, such as the wall, ceiling, floor, or furnishings. There the energy of the sound wave is partly absorbed and partly reflected, the extent of each depending on the nature of the surface it strikes. Reduction of the amount of sound reflected, therefore is essentially a matter of selection of materials for walls, floor, ceiling, and furnishings which will absorb the desired degree of sound.

In the control of sound where a speaker or music is to be heard, such as in a church or auditorium, reverberation time in the room should also be considered.

ABSORPTION CRITERIA

Three terms are introduced to define and evaluate sound absorption. These are the Sound Absorption Coefficient, Sabin, and Noise Reduction Coefficient.

The Sound Absorption Coefficient is a measure of the proportion of the sound striking a surface which is absorbed by that surface, and is usually given for a particular frequency. Thus, a surface which would absorb 100% of the incident sound would have a Sound Absorption Coefficient of 1.00, while a surface which absorbs 45% of the sound, and reflects 55% of it, would have a Sound Absorption Coefficient of 0.45. This usually varies with each frequency tested.

A Sabin or square-foot unit of absorption is defined as the amount of sound absorbed by one square foot of surface having a Sound Absorption Coefficient of 1.00. The number of Sabins (Absorption Units) of a given area is then the product of the area and the Sound Absorption Coefficient. 100 sq. ft. of a surface with a Sound Absorption Coefficient of 0.25 furnishes 25 Sabins (Absorption Units).

Most materials are tested at frequencies from 125 to 4000 cycles per second (cps) in octave steps. The Noise Reduction Coefficient is the average of the Sound Absorption Coefficient at 250, 500, 1000 and 2000 cps in octave steps. Table 6 lists approximate values of the Noise Reduction Coefficients of numerous materials.

TEXTURE

The Noise Reduction Coefficient of a surface is, to a large degree, dependent on the porosity of the material and the texture of the surface.

For example, a sheet of painted fiberboard with its relatively smooth paint covering would be expected to reflect a major portion of sound striking it, thereby furnishing low sound absorption. On the other hand, if the surface were punctured with a number of holes, sound could then penetrate the porous core, and be dissipated thus appreciably increasing its sound absorption.

Concrete masonry produced with expanded shale aggregate offers an extremely strong material with countless minute voids due to the technique of modern aggregate and block manufacture. These voids naturally appear on the surface of the unit, thereby permitting sound waves to enter the unit and be dissipated within the material, thus giving it fairly good sound absorbing properties.

Painting will tend to seal the surface. Tests indicate that the extent of sealing depends upon the type of paint and method of application. (See Table 6).

REVERBERATION

Reverberation is the persistence of sound within an enclosed space after the source of sound has been cut off. Its effect on hearing is to prolong syllables in speech or tones in music which, if not in the right range, make hearing difficult and irritating.

Reverberation time is defined as the time in seconds for the intensity level to fall 60 decibels. The factors which affect reverberation time are (1) the volume of the room and (2), the sound absorbing properties of the room's surfaces.

In rooms of small volume, such as offices, reverberation generally is not the major factor. In assembly areas where speech or music is to be heard, as in churches and auditoriums, an investigation of reverberation time is necessary.

Reverberation time may be computed by the formula developed by Prof. W. C. Sabine:

$$T = \frac{0.05V}{a} \quad \text{where}$$

T = reverberation time
V = volume of the room in cubic feet
a = absorption of the surfaces in sabins

The desirable reverberation times for hearing may be taken from the chart in Fig. 3. The shaded area on this chart represents acceptable reverberation times for various room sizes. When treating rooms for speech or with public address systems, the times should fall nearer the lower limit of tolerance. In churches or rooms designed for music or without public address systems, the times selected should fall nearer the upper limits.

SOUND ABSORPTION CALCULATIONS

Tabulated or tested values of the Sound Absorption Coefficient, plus the concept of the Sabin or Absorption Unit provide a means of estimating the total sound absorbed in a room, and permits a choice of materials to accomplish the desired value.

Experience of acoustical engineers has indicated that for noise reduction comfort, the total number of Absorption Units in a room (exclusive of the absorption provided by the occupants), should be between 20% and 50% of the total surface area. The lower range is generally satisfactory for enclosures such as offices and school rooms, whereas the upper range is desirable for such areas as libraries. Where a speaker or music is to be heard by an audience, reverberation time becomes the controlling factor in comfort design.

EXAMPLES

The following examples will serve to illustrate the calculations.

EXAMPLE NO. 1

An office 15 x 25 ft. with 9 foot ceilings: medium textured concrete masonry walls sprayed with two coats of latex base paint, asphalt tile floors, and acoustical tile ceiling. Interior Surface Area - (15x25x2)+(30+50)x9 = 1,470 sq. ft. 1,470x20% = 294, minimum number of Absorption Units desired for comfort.

Absorption Units Calculations (See Table 6 for Coefficients).

Floor	15x25	= 375 sq.ft. x 0.05	=	19.0
Ceiling	15x25	= 375 sq.ft. x 0.70	=	262.0
Walls	(30+50)x9	= 720 sq.ft.		
Window	6x4	= 24 sq.ft. x 0.02	=	0.5
Door	6.5x4	= 26 sq.ft. x 0.06	=	1.5
Masonry	720-(24+26)	= 670 sq.ft. x 0.36	=	241.0
		TOTAL		524.0

Since the total Absorption Units are greater than the minimum required, 294, and less than the maximum, 735, the office should be satisfactory.

EXAMPLE NO. 2

A school auditorium or assembly room without a public address system: room 50 ft. by 70 ft. in area with 20 ft. ceilings; stage 50 ft. by 30 ft. with a 10 ft. by 30 ft. opening. Asphalt tile flooring over concrete; walls of exposed expanded shale masonry of medium texture, sprayed with one coat of paint, windows occupy 75% of one 70 ft. wall; ceiling is exposed pre-cast expanded shale concrete channel slabs; removable metal chairs provided for seating 300 people.

Interior Surface Area 2(70 x 50) + (240 x 20)	= 11,800 sq.ft.
Absorption Units required for comfort 11,800 x 0.20	= 2,360 sabins
Floor 50 x 70 = 3,500 sq.ft. x 0.05	= 175
Ceiling 50 x 70 = 3,500 sq.ft. x 0.02	= 70
C/M Walls (170x20)+(70x20)0.25 = 3,750 sq.ft. x .40	= 1,500
Windows (70 x 20) x 0.75 = 1,050 sq.ft. x 0.02	= 21
Stage Opening 30 x 10 = 300 sq.ft. x 0.50	= 150
Total, bare room	= 1,916
Metal chairs — 300 x 0.20	= 60
Total for room	= 1,976

This is too low for our "Comfort Index", but since this is an enclosure where an audience listens to a speaker or an orchestra, reverberation time is the controlling factor.

Absorption Coefficient for a person is 4.2 sabins. As we fill room with people we must add 4.2 — 0.2 (coefficient for chair) = 4.0 sabins for each person.

Using formula $T = \frac{0.05V}{a}$

Courtesy of Acoustical Materials Assn.

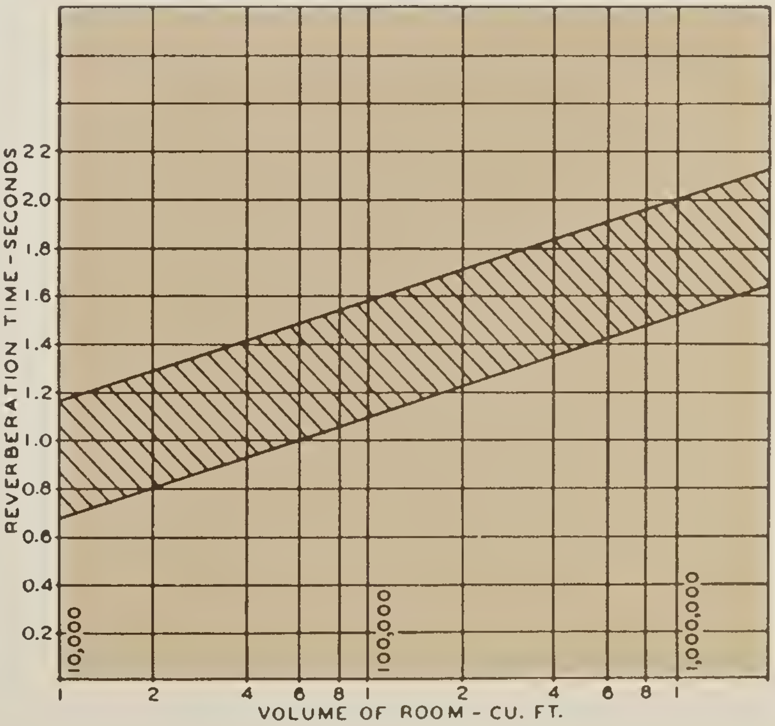


Fig. 3

AUDIENCE	ABSORPTION	T
None	1,976 sabins	1.8 sec.
75	2,276 "	1.5 "
150	2,576 "	1.4 "
225	2,876 "	1.2 "
300 (full)	3,176 "	1.1 "

Volume of the auditorium 70 x 50 x 20 = 70,000 cu.ft.

Referring to Figure 3, reverberation time for a room with a volume of 70,000 cubic feet should be between 1.0 and 1.5.

The room should be satisfactory after it becomes ¼ full. As it approaches ¾ to completely full, a public address system would be helpful.

TABLE 6. NOISE REDUCTION COEFFICIENTS

MATERIAL	APPROX. N.R.C.	
Expanded Shale Block, Medium Texture, unpainted	0.45	Add 10% for Coarse Texture Deduct 10% for Fine Texture
Heavy Aggregate Block, Medium Texture, unpainted	0.27	Add 5% for Coarse Texture Deduct 5% for Fine Texture

DEDUCTIONS FROM ABOVE FOR PAINTED BLOCK

PAINT TYPE	APPLICATION	ONE COAT	TWO COATS	THREE COATS
Any	Spray	10%	20%	70%
Oil Base	Brushed	20	55	75
Latex or Resin Base	Brushed	30	55	90
Cement Base	Brushed	60	90	—

MATERIAL	N.R.C.
Brick wall — unpainted	.05
Brick wall — painted	.02
Floors	
Concrete or terrazzo	.02
Wood	.03
Linoleum, asphalt, rubber or cork tile on concrete	.03 - .08
Glass	.02
Marble or glazed tile	.01
Plaster, gypsum or lime, smooth finish on tile or brick	.04
Same, on lath	.04
Plaster, gypsum or lime, rough finish on lath	.05
Plaster, acoustical	.21
Wood Panelling	.06
Acoustical Ceiling Tile	.55 - .85
Carpet, heavy, on concrete	.45
Carpet, heavy, hairfelt underlay	.70
Fabrics	
Light, 10 oz. per sq. yd. hung straight	.20
Medium, 14 oz. per sq. yd. draped to half area	.57
Heavy, 18 oz. per sq. yd. draped to half area	.63
Audience, seated, depending on character of seats, spacing, etc.	3.0 - 6.0
Chairs, metal or wood	.20
Wood Pews	.40
Same with cushions	2.0
Theatre and Auditorium Chairs	
Wood veneer seat and back	.50
Upholstered in leatherette	2.1
Heavily upholstered in plush or mohair	3.0 - 3.5
Openings	
Stage, depending on furnishings	.25 - .75
Deep balcony, upholstered seats	.50 - 1.00
Grilles, ventilating	.15 - .50

NYTRALITE VOLUME STABILITY

A better understanding of the recommendations for controlling volume change may be obtained by a discussion of drying shrinkage cracking. First, it should be clearly understood that shrinkage cracking rarely, if ever, has affected the structural stability of concrete masonry construction. The complaints regarding shrinkage cracking generally have been from the point of view of appearance. Fortunately, objectionable cracking of expanded shale masonry walls throughout the years has been infrequent. Obviously this has been due to the uniformly high quality of the aggregate and the adaptation of technically sound and proven methods of manufacturing expanded shale concrete masonry.

VOLUME CHANGE

A characteristic of portland cement is its tendency to decrease in volume with a decrease in moisture content. The drying out of a masonry wall will produce a tendency for it to shrink which, if the wall is restrained, will result in tensile stresses. If these stresses exceed the tensile strength of the wall, cracking will occur. It follows that in a given situation shrinkage stress up to a certain magnitude can be tolerated without cracking, whereas a slightly greater stress will produce a stress-relieving crack. To pin-point the critical value for all cases is rather difficult, however, current investigations throughout the concrete masonry industry are promising.

Unit shrinkage of a concrete masonry unit is dependent on:

(1) The chemical and physical properties of the aggregate;
(2) The chemical and physical properties of the cement;
(3) The gradation of the aggregate;
(4) The elastic properties of the aggregate;
(5) The proportion of cement to aggregate in the mix;
(6) The method of curing the unit;
(7) The tensile strength of the unit;
(8) The elastic properties of the unit; and
(9) The design of the unit.

Investigations are in progress to determine the significance of these factors and to improve the stability of concrete masonry.

MOISTURE CONTENT

To control objectionable cracking, limits have been placed on the moisture content of concrete masonry at the time of delivery. For many years this limitation, as designated by ASTM, was 40% of total absorption. In the early 1950's some specifications (not ASTM) reduced this limitation to 30% and, in arid regions, to 25% of total absorption.

Many studies of concrete masonry shrinkage and methods of measuring shrinkage have been in progress since the late 1940's. Recently through the cooperative studies of block manufacturers, Universities, Government agencies, trade associations and others, moisture content requirements based on the potential shrinkage, as determined by ASTM C-426 of the concrete masonry unit was adopted by ASTM C-90-64T.

In this specification two types of units are designated; Type I, Moisture-Controlled, and Type II, Non-Moisture Controlled. The Type I units must comply with the moisture contents designated in the following table:

TABLE 7

MOISTURE CONTENT REQUIREMENTS
FOR TYPE I UNITS

Linear Shrinkage,[b] Per Cent	Moisture Content, max, per cent of Total Absorption (Average of 5 Units)		
	Avg Annual RH, per cent[a]		
	Over 75	75 to 50	Under 50
0.03 or less	45	40	35
From 0.03 and 0.045	40	35	30
0.045 or more	35	30	25

[a] Based upon U. S. Weather Bureau records and 4 readings every 24 hr, at 6-hr intervals, as reported by the U. S. Weather Bureau Station nearest the source of manufacture.

[b] Method of Test for Drying Shrinkage of Concrete Block (ASTM Designation: C426) conducted not more than 12 months prior to delivery of units.

GOOD PRACTICE

As the many investigations continue, the following recommendations are a sound approach in minimizing objectionable cracking in a practical and economical manner:

(1) Choice of a concrete masonry unit with favorable dimensional stability;

(2) Keeping masonry units as dry as possible at all stages, particularly during site storage as well as during laying operations;

(3) The use of prefabricated or other joint reinforcement;

(4) Providing control joints and other details to allow more freedom of construction without overstressing; and

(5) The use of bond beams.

DIMENSIONAL STABILITY

Expanded shale concrete masonry maufacturers have at their disposal a lightweight aggregate developed and produced principally for making structural lightweight concrete. They also have at their disposal technical information and modern equipment for manufacturing and curing concrete masonry. As a result expanded shale masonry units uniformly have relatively low shrinkage compared with other lightweight masonry.

PROTECTION ON SITE

The following precautions should be observed:

(1) Masonry units should be stacked with separators on planks off the ground to allow air circulation and to avoid absorption of moisture from the ground;

(2) In wet weather storage piles should be covered;

(3) Concrete masonry units should not be dampened prior to laying*; and

(4) Work in progress should be covered at the top whenever work is suspended, to prevent water from entering the wall.

JOINT REINFORCEMENT

The use of prefabricated joint reinforcement, readily available in most areas, has proved to be effective in the control of drying shrinkage cracking. While it will not necessarily eliminate all cracks, those that occur will be extremely small and scarcely noticeable. Joint reinforcement also adds strength to the wall to assist in cases of unpredictable settlement or lateral loads.

The extent of joint reinforcement required depends on the characteristics of the masonry unit, the length and height of the wall, the location of openings, and the spacing of control joints. In general, it should be used for two consecutive joints above and below windows and at other openings (unless bracketed with control joints), extending 24" beyond the opening on each side.

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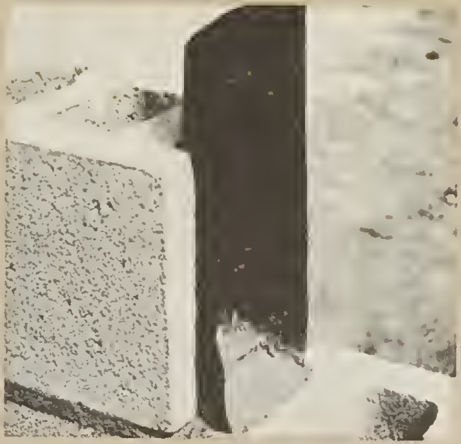
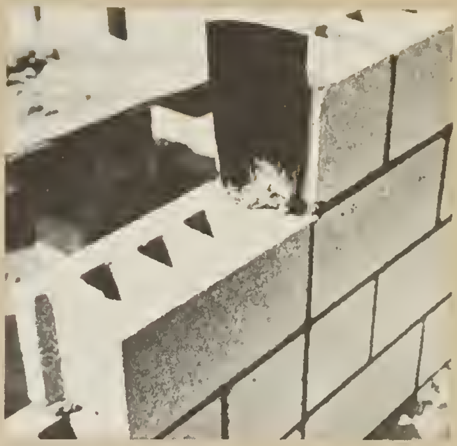
*In certain areas during protracted periods of hot and dry climate conditions it may be necessary to dampen block just prior to laying. It is suggested that local good practices be followed in these extreme conditions.

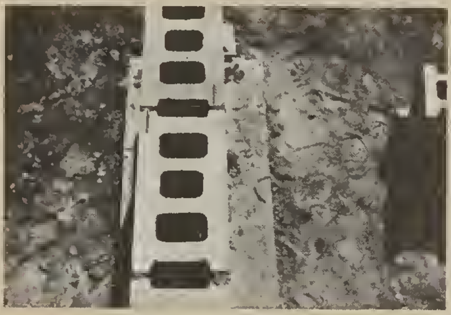
Control joint blocks are also made in full- and half-length units.



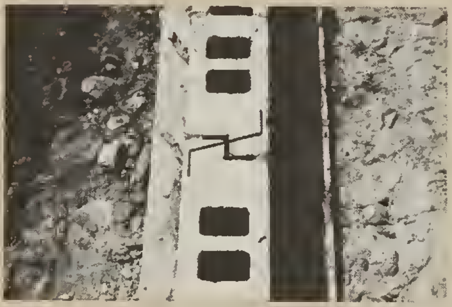
The paper or felt, across the joint, prevents the mortar from bonding.



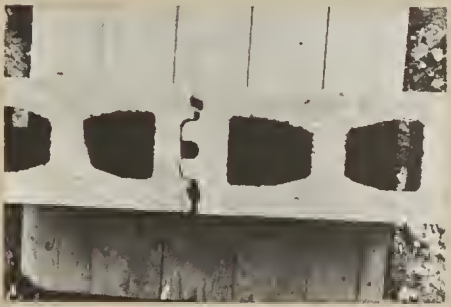
Building paper or roofing felt, inserted in the end cores, extend the full length of the control joint.



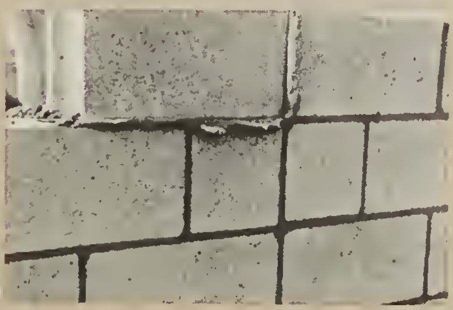
Control joints built with stretcher block have noncorroding Z-tiebars to provide lateral support.



Offset jamb block are used with a noncorroding metal tie laid across the joint.



A control joint block provides lateral support by means of tongue-and-groove-shaped ends.



To form a continuous vertcial joint, full- and half-length block are used.

CONTROL JOINTS

Control joints are vertical joints which provide continuous separation in the masonry to allow freedom of movement. The adjacent photographs show typical installations.

Control joints should be located where cracking would be most likely to occur in long straight walls, and at other points of potential excess tensile stress such as abrupt changes in wall thickness, chases for pipes, or at openings, unless protected by reinforcement. They may also be used at wall intersections, at intersections of partitions and main walls and at locations of structural columns in main walls or partitions.

BOND BEAMS

The function of a bond beam is:

(1) To act as a continuous interlocking structural tie connecting the exterior load bearing walls of structures whose dimensions do not require expansion or contraction joints. They may be used between the expansion joints of larger buildings;

(2) As a structural member transmitting lateral loads on the structure to other structural elements;

(3) To reduce the effects on the masonry of differential volume changes between the foundation and superstructure walls; and

(4) As a solid member to provide bearing for floor joists or beams and to distribute concentrated loads.

In addition to the structural function, bond beams help to minimize shrinkage in masonry above and below openings.

A typical bond beam consists of a "bond beam" or "lintel" unit of the same material and texture as the wall block. They are filled in place with 2500 p.s.i. concrete and reinforced with a minimum of two No. 4 bars.

MORTAR

The functions of a mortar in a masonry wall are threefold:

(1) To bind the masonry units into an integrated, stable and permanent element.

(2) To effectively resist the passage of moisture either through or between it and the masonry unit.

(3) To complement the masonry unit in providing a neat and pleasing appearance.

Since the mortar is an integral part of the wall, and since some characteristics of the mortar materially affect the quality of workmanship obtained, the mortar should be designed and specified with the same care as the masonry unit itself.

Generally, the requirements of "Tentative Specifications for Mortar for Unit Masonry" — A.S.T.M. Designation C270 — may be followed except where other federal, municipal and special codes apply.

WATER RETENTIVITY

A.S.T.M. C270 requires that mortars, mixed to an initial flow of 100 to 115, shall have a flow after suction of not less than 70%.

This applies to all classifications of mortars. It is a most important requirement and should be strictly adhered to. This flow is a measure of the water retentivity of the mortar, that is, its ability to resist the rapid loss of water into dry absorptive units or to bleeding when in contact with nonabsorptive units.

Water retentivity is essential because:

(1) It increases workability;

(2) It assures a good bond to the masonry;

(3) It keeps the mortar plastic, cohesive and adhesive;

(4) It resists the rapid loss of water into absorptive units; and

(5) It resists bleeding of the mortar.

Where materials are available as plasticizers and water retaining agents, which meet with local code requirements and/or A.S.T.M. Designation: C270, they may be used in accordance with manufacturer's specifications.

STRENGTH

The strength of the mortar is primarily a function of proportion of cement to sand in the mix, but is also affected by its workability and the retention of the needed water for hydration. Mortar strength is also an indication of its durability, and therefore high strength mortars must be used in severe conditions. Table 4 shows 3 mortar types and their required compressive strength at 7 and 28 days, on 2-in. cubes.

ASTM SPECIFICATIONS

A.S.T.M. Designation C270 covers five types of mortars in each of two alternate specifications. These are "Property Specifications" and "Proportion Specifications." The specification writer should specify one or the other (not both), depending upon the circumstances of the specific job.

PROPERTY SPECIFICATIONS

Mortar shall comply with A.S.T.M. C270 in all respects as it applies to property specifications. Mortar shall be type M, S or N having minimum compressive strength and water retention as shown in Table 4, when tested in accordance with A.S.T.M. C270.

PROPORTION SPECIFICATIONS

Mortar shall comply with A.S.T.M. C270 with proportions as shown in Table 5. Mortar shall be type M, S or N.

ORGANIC ADHESIVES

Investigations are progressing in the application of organic adhesives for concrete masonry bonding agents. Encouraging results are being found in formulations based on epoxy resin and polyester resin systems, and organic resin latex systems as modifiers for conventional mortars.

World's Fair N. Y. State Pavilion—Nytralite Masonry Units Used

World's Fair Festival of Gas Pavilion—Nytralite Masonry Units Used

NYTRALITE THERMAL INSULATION

OF VARIOUS WALLS

With the many improvements being made in heating and air conditioning equipment for residences, commercial and office buildings, hotels, industrial buildings and the like, it is becoming increasingly important for architects and engineers to have ready access to information on the thermal insulation properties of building materials. This bulletin furnishes convenient information on insulating values of various walls and their components.

Since the mechanical engineer designs the heating and cooling plant on the basis of the total hourly heat transmission through the exterior parts of the building, optimum efficiency in economical structural design requires analysis of the relative heat losses through the elements of the structure. This data sheet has been prepared to present values on a number of commonly used building materials, and to aid in designing more economical structures.

The values shown in this bulletin are based on the Heating, Ventilating and Air Conditioning Guide and may be used directly for steady state heat transmission calculations. Reference should be made to the Guide when further detailed studies are desired.

Nomenclature as used in the Guide for heat loss calculations is as follows:

U = overall coefficient of heat transmission or thermal transmittance (air to air); the time rate of heat flow expressed in Btu per (hour) (square foot) (Fahrenheit degree temperature difference between air on the inside and air on the outside of a wall, floor, roof or ceiling). The term is applied to the usual combinations of materials, and also to single materials, such as window glass, and includes the surface conductance on both sides. This term is frequently called the U value.

k = thermal conductivity; the time rate of heat flow through a homogeneous material under steady conditions (through unit area per unit temperature gradient in the direction of the gradient.) Its value is expressed in Btu per (hour) (square foot) (Fahrenheit degrees per inch of thickness). Materials are considered homogeneous when the value of k is not affected by variation in thickness or size of sample within the range normally used in construction.

C = thermal conductance; the time rate of heat flow through a unit area of a material from one of its surfaces to the other per unit temperature difference between the two surfaces. Its value is expressed in Btu per (hour) (square foot) (Fahrenheit degree). The term is applied to specific materials as used, either homogeneous or heterogeneous.

f = film or surface conductance; the time rate of heat flow between a unit area of a surface and the surrounding air. Its value is expressed in Btu per (hour) (square foot of surface) (Fahrenheit degree temperature difference). Subscripts i and o are used to differentiate between inside and outside surface conductances, respectively.

a = thermal conductance of an air space; the time rate of heat flow through a unit area of an air space per unit temperature difference between the boundary surfaces. Its value is expressed in Btu per (hour) (square foot of area) (Fahrenheit degree). The conductance of an air space is dependent on the temperature difference, the height, the depth, the position and the character and temperature of the boundary surfaces. Since the relationships are not linear, accurate values must be obtained by test and not by computation.

R = thermal resistance. Its value is obtained from the reciprocal of heat transfer as expressed by U, k, C, f or a. It is expressed in (hours) (square feet) (Fahrenheit degrees) per (Btu). For example, a wall with a U value of 0.25 would have a resistance value of R = 1/0.25 = 4.0. Therefore, 4 hours would be required for the transfer of one Btu for each square foot of area and each degree of temperature differential. (In some cases resistance is expressed in the alternate form of Degrees F per (Btu/hour square foot).)

The coefficient of heat transmission U of a construction is calculated as the reciprocal of R_T which is the sum of the resistances of the various components of the wall including air spaces and surface films.

Table II lists the resistances from which the sum R_T can be obtained.

Example: Assume initial trial design of an 8″ sand-gravel concrete masonry wall, furred and plastered.

Referring to Table II:

		R
$1/f_o$	Outside surface conductance	.17
1/C	8 x 8 x 16 concrete masonry, sand & gravel	1.11
1/a	Air space (Average of Summer & Winter values)	.91
1/C	Rock lath, ⅜″ thick	.32
1/C	Sand-gypsum plaster, ½″	.09
$1/f_i$	inside surface conductance	.68
	$R_T =$	3.28

$$U = \frac{1}{R_T} = 0.30$$

This heat loss may be acceptable under moderate climatic conditions. Where such conditions do not exist, changes in this design will be required.

Let us assume that climatic conditions dictate a heat loss of 0.25 Btu per square foot per hour, or less. This will require an R_T of 4.00, or additional resistance of 4.00—3.28 = 0.72.

Referring to Table II, it is noted that the difference in the resistances of 8″ sand and gravel and expanded shale masonry is 2.00—1.11 = 0.89.

Substituting expanded shale for sand and gravel masonry results in the initial trial design becoming $R_T = 3.28 + 0.89 = 4.17$ and U becomes 0.24, which satisfies the requirement selected.

Table I provides the calculated values of the overall coefficient of heat transmission U and total resistance R_T for a number of different composite walls. The use of this table by the architect and engineer generally will permit the selection of wall design that will economically and readily meet insulation requirements without the necessity of calculations from the data listed in Table II.

TABLE I

WALL CONSTRUCTION

NOTE: Surface Resistances included in "R" for Interior Wall Treatments.

Wall No.	Interior Wall Treatment Resist. →		R	Plain Wall No Plaster R = 0.85 RT	Plain Wall No Plaster R = 0.85 U	Plaster Direct On Wall: Gyp-Sand Plaster R = 0.94 RT	Plaster Direct On Wall: Gyp-Sand Plaster R = 0.94 U	Plaster Direct On Wall: Gyp-Lt. Wt. Plaster R = 1.17 RT	Plaster Direct On Wall: Gyp-Lt. Wt. Plaster R = 1.17
	CAST IN PLACE OR PRE-CAST CONCRETE								
1	8" Sand & Gravel Aggregate	140 pcf.	0.88	1.73	0.58	1.82	0.55	2.05	0.4
2	8" Expanded Shale Clay or Slate Aggregate	100 pcf.	2.24	3.09	0.32	3.18	0.31	3.41	0.2
3	8" Expanded Shale Clay or Slate Aggregate	95 pcf.	2.40	3.25	0.31	3.34	0.30	3.57	0.2
4	8" Expanded Shale Clay or Slate Aggregate	90 pcf.	2.56	3.41	0.29	3.50	0.29	3.73	0.2
5	8" Expanded Shale Clay or Slate Aggregate	85 pcf.	2.88	3.73	0.27	3.82	0.26	4.05	0.2
6	6" Sand & Gravel Aggregate	140 pcf.	0.66	1.51	0.66	1.60	0.63	1.83	0.5
7	6" Expanded Shale Clay or Slate Aggregate	100 pcf.	1.68	2.53	0.40	2.62	0.38	2.85	0.3
8	6" Expanded Shale Clay or Slate Aggregate	95 pcf.	1.80	2.65	0.38	2.74	0.37	2.97	0.3
9	6" Expanded Shale Clay or Slate Aggregate	90 pcf.	1.92	2.77	0.36	2.86	0.35	3.09	0.3
10	6" Expanded Shale Clay or Slate Aggregate	85 pcf.	2.16	3.01	0.33	3.10	0.32	3.33	0.3
	CONCRETE MASONRY								
11	12" Sand & Gravel Aggregate		1.28	2.13	0.47	2.22	0.45	2.45	0.4
12	12" Cinder Aggregate		1.89	2.74	0.37	2.83	0.35	3.06	0.3
13	12" Expanded Shale Clay or Slate Aggregate		2.27	3.12	0.32	3.21	0.31	3.44	0.2
14	8" Sand & Gravel Aggregate		1.11	1.96	0.51	2.05	0.49	2.28	0.
15	8" Cinder Aggregate		1.72	2.57	0.39	2.66	0.38	2.89	0.
16	8" Expanded Shale Clay or Slate Aggregate		2.00	2.85	0.35	2.94	0.34	3.17	0.
	4 INCH FACE BRICK PLUS								
17	4" Common Brick		1.24	2.09	0.48	2.18	0.46	2.41	0.
18	4" Clay Tile		1.55	2.40	0.42	2.49	0.40	2.72	0.
	4" Concrete Masonry								
19	Sand & Gravel Aggregate		1.15	2.00	0.50	2.09	0.48	2.32	0.
20	Cinder Aggregate		1.55	2.40	0.42	2.49	0.40	2.72	0.
21	Expanded Shale Clay or Slate Aggregate		1.94	2.79	0.36	2.88	0.35	3.11	0.
22	1" Wood Sheathing, 2" x 4" Studs		(1.54)	--	--	--	--	--	
	4 INCH COMMON BRICK PLUS								
23	4" Common Brick		1.60	2.45	0.41	2.54	0.39	2.77	0.
24	4" Clay Tile		1.91	2.76	0.36	2.85	0.35	3.08	0.
	4" Concrete Masonry								
25	Sand & Gravel Aggregate		1.51	2.36	0.42	2.45	0.41	2.68	0.
26	Cinder Aggregate		1.91	2.76	0.36	2.85	0.35	3.08	0.
27	Expanded Shale Clay or Slate Aggregate		2.30	3.15	0.32	3.24	0.31	3.47	0.
28	1" Wood Sheathing, 2" x 4" Studs		(1.90)	--	--	--	--	--	
	WOOD CONSTRUCTION								
29	Bevel Siding - 1/2" x 8" Lapped, Building Paper, Wood Sheathing, 2" x 4" Studs		(1.91)	--	--	--	--	--	
	CAVITY WALLS (Built with two units, separated by 1" or larger air space)								
	9-Inch Wall								
30	4" Face Brick & 4" Common Brick		2.15	3.00	0.33	3.09	0.32	3.32	0.
	4" Face Brick & 4" Concrete Masonry								
31	Sand & Gravel Aggregate		2.06	2.91	0.34	3.00	0.33	3.23	0.
32	Cinder Aggregate		2.46	3.31	0.30	3.40	0.29	3.63	0.
33	Expanded Shale Clay or Slate Aggregate		2.85	3.70	0.27	3.79	0.26	4.02	0.
	4" Concrete Masonry & 4" Concrete Masonry								
34	Sand & Gravel Aggregate		2.33	3.18	0.31	3.27	0.31	3.50	0.
35	Cinder Aggregate		3.13	3.98	0.25	4.07	0.25	4.30	0.
36	Expanded Shale Clay or Slate Aggregate		3.91	4.76	0.21	4.85	0.21	5.08	0.
	13-INCH WALL								
	4" Face Brick & 8" Concrete Masonry								
37	Sand & Gravel Aggregate		2.46	3.31	0.30	3.40	0.29	3.63	0.
38	Cinder Aggregate		3.07	3.92	0.26	4.01	0.25	4.24	0.
39	Expanded Shale Clay or Slate Aggregate		3.35	4.20	0.24	4.29	0.23	4.52	0.
	4" Concrete Masonry & 8" Concrete Masonry								
40	Sand & Gravel Aggregate		2.73	3.58	0.28	3.67	0.27	3.90	0.
41	Cinder Aggregate		3.74	4.59	0.22	4.68	0.21	4.91	0.
42	Expanded Shale Clay or Slate Aggregate		4.41	5.26	0.19	5.35	0.19	5.58	0.

NOTE: The average of Winter and Summer values for air space conductance is used in these calculations i.e. $\frac{.97 + .86}{2} = 0.91$.

3/4 INCH FURRING															
										One Side Air Space Reflective Insulation					
3/8" Gypsum Lath				1/2" Gyp. Board Dry Wall		1/2 Inch Fiber Insulation Board				3/8" Gypsum Lath				1/2"Gyp.Board Dry-Wall	
yp-Sand Plaster		Gyp-Lt.Wt. Plaster				Gyp-Sand Plaster		Gyp-Lt. Wt. Plaster		Gyp-Sand Plaster		Gyp-Lt. Wt. Plaster			
R = 2.17		R = 2.40		R = 2.21		R = 3.28		R = 3.51		R = 4.26		R = 4.49		R = 4.30	
T	U	R_T	U	R_T	U	R_T	U	R_T	U	R_T	U	R_T	U	R_T	U
3.05	0.33	3.28	0.30	3.09	0.32	4.16	0.24	4.39	0.23	5.14	0.19	5.37	0.19	5.18	0.19
4.41	0.23	4.64	0.22	4.45	0.22	5.52	0.18	5.75	0.17	6.50	0.15	6.73	0.15	6.54	0.15
4.57	0.22	4.80	0.21	4.61	0.22	5.68	0.18	5.91	0.17	6.66	0.15	6.89	0.15	6.70	0.15
4.73	0.21	4.96	0.20	4.77	0.21	5.84	0.17	6.07	0.16	6.82	0.15	7.05	0.14	6.86	0.15
5.05	0.20	5.28	0.19	5.09	0.20	6.16	0.16	6.39	0.16	7.14	0.14	7.37	0.14	7.18	0.14
2.83	0.35	3.06	0.33	2.87	0.35	3.94	0.25	4.17	0.24	4.92	0.20	5.15	0.19	4.96	0.20
3.85	0.26	4.08	0.25	3.89	0.26	4.96	0.20	5.19	0.19	5.94	0.17	6.17	0.16	5.98	0.17
3.97	0.25	4.20	0.24	4.01	0.25	5.08	0.20	5.31	0.19	6.06	0.17	6.29	0.16	6.10	0.16
4.09	0.24	4.32	0.23	4.13	0.24	5.20	0.19	5.43	0.18	6.18	0.16	6.41	0.16	6.22	0.16
4.33	0.23	4.56	0.22	4.37	0.23	5.44	0.18	5.67	0.18	6.42	0.16	6.65	0.15	6.46	0.15
3.45	0.29	3.68	0.27	3.49	0.29	4.56	0.22	4.79	0.21	5.54	0.18	5.77	0.17	5.58	0.18
4.06	0.25	4.29	0.23	4.10	0.24	5.17	0.19	5.40	0.19	6.15	0.16	6.38	0.16	6.19	0.16
4.44	0.23	4.67	0.21	4.48	0.22	5.55	0.18	5.78	0.17	6.53	0.15	6.76	0.15	6.57	0.15
3.28	0.30	3.51	0.29	3.32	0.30	4.39	0.23	4.62	0.22	5.37	0.19	5.60	0.18	5.41	0.18
3.89	0.26	4.12	0.24	3.93	0.25	5.00	0.20	5.23	0.19	5.98	0.17	6.21	0.16	6.02	0.17
4.17	0.24	4.40	0.23	4.21	0.24	5.28	0.19	5.51	0.18	6.26	0.16	6.49	0.15	6.30	0.16
3.41	0.29	3.64	0.27	3.45	0.29	4.52	0.22	4.75	0.21	5.50	0.18	5.73	0.17	5.54	0.18
3.72	0.27	3.95	0.25	3.76	0.27	4.83	0.21	5.06	0.20	5.81	0.17	6.04	0.17	5.85	0.17
3.32	0.30	3.55	0.28	3.36	0.30	4.43	0.23	4.66	0.21	5.41	0.18	5.64	0.18	5.45	0.18
3.72	0.27	3.95	0.25	3.76	0.27	4.83	0.21	5.06	0.20	5.81	0.17	6.04	0.17	5.85	0.17
4.11	0.24	4.34	0.23	4.15	0.24	5.22	0.19	5.45	0.18	6.20	0.16	6.43	0.16	6.24	0.16
3.71	0.27	3.94	0.25	3.75	0.27	4.82	0.21	5.05	0.20	5.80	0.17	6.03	0.17	5.84	0.17
3.77	0.27	4.00	0.25	3.81	0.26	4.88	0.20	5.11	0.20	5.86	0.17	6.09	0.16	5.90	0.17
4.08	0.25	4.31	0.23	4.12	0.24	5.19	0.19	5.42	0.18	6.17	0.16	6.40	0.16	6.21	0.16
3.68	0.27	3.91	0.26	3.72	0.27	4.79	0.21	5.02	0.20	5.77	0.17	6.00	0.17	5.81	0.17
4.08	0.25	4.31	0.23	4.12	0.24	5.19	0.19	5.42	0.18	6.17	0.16	6.40	0.16	6.21	0.16
4.47	0.22	4.70	0.21	4.51	0.22	5.58	0.18	5.81	0.17	6.56	0.15	6.79	0.15	6.60	0.15
4.07	0.25	4.30	0.23	4.11	0.24	5.18	0.19	5.41	0.18	6.16	0.16	6.39	0.16	6.20	0.16
4.08	0.25	4.31	0.23	4.12	0.24	5.19	0.19	5.42	0.18	6.17	0.16	6.40	0.16	6.21	0.16
4.32	0.23	4.55	0.22	4.36	0.23	5.43	0.18	5.66	0.18	6.41	0.16	6.64	0.15	6.45	0.16
4.23	0.24	4.46	0.22	4.27	0.23	5.34	0.19	5.57	0.18	6.32	0.16	6.55	0.15	6.36	0.16
4.63	0.22	4.86	0.21	4.67	0.21	5.74	0.17	5.97	0.17	6.72	0.15	6.95	0.14	6.76	0.15
5.02	0.20	5.25	0.19	5.06	0.20	6.13	0.16	6.36	0.16	7.11	0.14	7.34	0.14	7.15	0.14
4.50	0.22	4.73	0.21	4.54	0.22	5.61	0.18	5.84	0.17	6.59	0.15	6.82	0.15	6.63	0.15
5.30	0.19	5.53	0.18	5.34	0.19	6.41	0.16	6.64	0.15	7.39	0.14	7.62	0.13	7.43	0.13
6.08	0.16	6.31	0.16	6.12	0.16	7.19	0.14	7.42	0.13	8.17	0.12	8.40	0.12	8.21	0.12
4.63	0.22	4.86	0.21	4.67	0.21	5.74	0.17	5.97	0.17	6.72	0.15	6.95	0.14	6.76	0.15
5.24	0.19	5.47	0.18	5.28	0.19	6.35	0.16	6.58	0.15	7.33	0.14	7.56	0.13	7.37	0.14
5.52	0.18	5.75	0.17	5.56	0.18	6.63	0.15	6.86	0.15	7.61	0.13	7.84	0.13	7.65	0.13
4.90	0.20	5.13	0.19	4.94	0.20	6.01	0.17	6.24	0.16	6.99	0.14	7.22	0.14	7.03	0.14
5.91	0.17	6.14	0.16	5.95	0.17	7.02	0.14	7.25	0.14	8.00	0.13	8.23	0.12	8.04	0.12
6.58	0.15	6.81	0.15	6.62	0.15	7.69	0.13	7.92	0.13	8.67	0.12	8.90	0.11	8.71	0.11

TABLE II

MATERIAL	Thickness (Inches)	Density p.c.f.	Conductivity or Conductance		Resistance	
			k	C	1/k	1/C
CONCRETE						
Sand and gravel aggregate		140	9.00		0.11	
Expanded shale clay or slate aggregate		100	3.60		0.28	
Expanded shale clay or slate aggregate		95	3.30		0.30	
Expanded shale clay or slate aggregate		90	3.10		0.32	
Expanded shale clay or slate aggregate		85	2.80		0.36	
Expanded shale clay or slate aggregate		80	2.50		0.40	
Expanded shale clay or slate aggregate		75	2.30		0.43	
Expanded shale clay or slate aggregate		70	2.10		0.48	
Cement Mortar and Stucco		116	5.00		0.20	
CLAY MASONRY						
Hollow clay tile	4			0.90		1.11
Face Brick		130	9.00		0.11	
Common Brick		120	5.00		0.20	
CONCRETE MASONRY						
12–8–16						
Sand and gravel aggregate	12			0.78		1.28
Cinder aggregate	12			0.53		1.89
Expanded shale, clay or slate aggregate	12			0.44		2.27
8–8–16						
Sand and gravel aggregate	8			0.90		1.11
Cinder aggregate	8			0.58		1.72
Expanded shale, clay or slate aggregate	8			0.50		2.00
6–8–16 (estimated)						
Sand and gravel aggregate	6			1.1		0.9
Cinder aggregate	6			.7		1.4
Expanded shale, clay or slate aggregate	6			.6		1.8
4–8–16						
Sand and gravel aggregate	4			1.40		0.71
Cinder aggregate	4			0.90		1.11
Expanded shale, clay or slate aggregate	4			0.67		1.50
FRAME CONSTRUCTION						
Siding						
Wood, Drop 1" x 8"				1.27		0.79
Wood, Bevel 1/2" x 8" lapped				1.23		0.81
Wood, Bevel 3/4" x 10" lapped				0.95		1.05
Shingles						
Wood, 16-in. 7½" exposure				1.15		0.87
Wood, double, 16-in. 12" exposure				0.84		1.19
Asbestos-cement		120		4.76		0.21
Sheathing or Building Board						
Wood, fir or pine	25/32			1.02		0.98
Wood fiber, hardboard type	1/4	65		5.60		0.18
Plywood	3/8	34		2.12		0.47
Plywood or wood panels	3/4			1.07		0.94
Wood or cane fiber, impregnated	25/32	20		0.49		2.06
Gypsum or plaster board	3/8	50		3.10		0.32
Gypsum or plaster board	1/2	50		2.25		0.45
Building Paper						
Vapor-permeable felt				16.70		0.06
Vapor-seal, 2 layers mopped 15 lb. felt				8.35		0.12
INSULATION						
Blanket or Batts						
Mineral wool, processed from rock, slag, or glass		1.5–4.0	0.27		3.70	
Wood fiber		3.2–3.6	0.25		4.00	
Loose Fill						
Mineral wool (glass, slag, or rock)		2.0–5.0	0.30		3.33	
Vermiculite (expanded)		7.0	0.48		2.08	
Saw dust or shavings		8.0–15.0	0.45		2.22	
Board						
Corkboard		6.5–8.0	0.27		3.70	
Fiber, wood or cane (interior finish)	1/2	15		0.70		1.43
Glass fiber		9.5	0.25		4.00	
Wood shredded (with cement binder)		22.0	0.55		1.82	
Cellular glass		9.0	0.40		2.50	
PLASTER						
Cement plaster, sand aggregate	1/2	116		10.00		0.10
Gypsum plaster						
Sand aggregate	1/2	105		11.10		0.09
Sand aggregate	5/8	105		9.10		0.11
Lightweight aggregate	1/2	45		3.12		0.32
Lightweight aggregate	5/8	45		2.67		0.39
Perlite aggregate		45	1.5		0.67	
Vermiculite aggregate		45	1.7		0.59	
SURFACE CONDUCTANCE						
f_o -- for outside wall, 15 mile per hr. wind (winter)				6.00		0.17
f_o -- for outside wall, 7½ mile per hr. wind (summer)				4.00		0.25
f_i -- for inside wall				1.46		0.68
AIR SPACE CONDUCTANCE						
Vertical air space 3/4" – 4'						
Winter				1.03		0.97
Summer				1.16		0.86
Reflective lining one side				0.33		3.00

FARMERS-MATTEAWAN NATIONAL BANK-DRIVE IN
FARMERS - MATTEAWAN NATIONAL BANK
DRIVE IN ENTRANCE
SHOP-RITE
ALEXANDER HAMILTON HOUSES
A DEVELOPMENT OF
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